This article was written by Ken Robinson, a much-respected contractor, in September 1990 and document his experiences while conducting shipboard industrial ventilation evaluations. His evaluations resulted in recommendations for the ships of the 21st Century. Mr. Robinson is also one of the original committee members who wrote the primer on industrial ventilation.

VENTILATION OF NAVAL SHIPS

Introduction. Some time ago, arrangements were made for me to visit two ships at Norfolk for the purpose of observing some of the ventilation systems.

Today I am here to give an outsiders overview of the on board ship Navy ventilation program--not to criticize. Also, to offer suggestions for improving the present ventilation systems and to discuss things that should be considered and different approaches that might be incorporated in the design of ships for the 21st century.

The most logical approach seems to be to break the subject into three parts. They are:

a. What people aboard the ship can do to improve the existing ventilation.

b. Changes in the way the people dock side carry out alterations to ventilation systems when a ship is in port.

c. Suggestions that may be helpful in the planning of ships for the 21st century.

Before getting into the discussion there are some definitions and explanations that I would like to offer to help everyone better understand the suggestions that will be forthcoming, these include:

1. A good working definition of ventilation is the simultaneous supply and exhausting of air from a space.

2. Heating, cooling and air-conditioning; and industrial ventilation are two distinct and different phases of ventilation and should always be discussed separately.

3. The acceptable high and low temperatures for people both at rest or working are becoming more critical.

4. Uncontrolled high temperatures at workstations are no longer acceptable.

5. Industrial operations are generating more airborne toxic materials and industrial hygienists are becoming more aware of the toxicity, as are the industrial workers. This results in a demand for better control of the airborne industrial contaminants.

6. In the near future, more on board inspections by state and local authorities, when the ship is in port, can be expected.

7. Only by communication and cooperation between ventilation engineers and industrial hygienist, can industrial health problems be determined and controlled.

8. Many qualified industrial ventilation engineers believe that an engineer must field test some ventilation systems before they are truly qualified to design systems.

9. Studies by the School of Public Health, at the University of Michigan disclosed that one can get an engineering degree at any college of engineering in the U.S. and not be exposed to, or even hear the term, industrial ventilation. This means that few, if any, engineers at graduation have any real knowledge of the basics of airflow or the best hood design for the control of airborne contaminants.

The American Industrial Hygiene Association (AIHA) publishes a manual, Heating and Cooling of Man in Industry, that explains how to control the workplace temperature.

The Air Moving and Control Association (AMCA) publishes a manual, Systems 201, that provides information as to how much a fan is derated when bad fittings are connected to the inlet or outlet of the fan and how to select a fan to overcome these problems.

Many qualified industrial ventilation engineers, believe that an engineer is not capable of good design unless he has tested an evaluated a number of ventilation systems in the field.

The problem: A great deal of information as how equipment is to be installed aboard a Navy ship is provided in Section 512, under the heading Heating, Ventilation, and Air Conditioning. The Manual of Naval Preventive Medicine, Chapter 3, Ventilation and Thermal Stress Ashore and Afloat, gives some information on ventilation, but it is mostly directed to heat stress.

Observations and information received both aboard ship and on the base, left a strong impression that people responsible for the installation of ventilation are so involved with the numbers provided in their manuals, they have forgotten that the purpose of ventilation is to provide a suitable place for people to work. Perhaps this happens because of lack of training in the use of ventilation for environmental control.

This may not be true--the problem may be that there is little or no information provided as to how to install air supply and exhaust to control heat and other airborne contaminants.

The information on the use of air movement to reduce heat stress, while incomplete as regards design, control and direction of air supply, does provide statements about velocities that are not acceptable by people in industry working at hot operations.

The lack of control of heat and steam in the laundries and galleys resulted in deplorable conditions that would not be acceptable in commercial operations. After observing these operations we could understand statements that the temperature in these two locations were the most objectionable aboard ship.

What can be done aboard ship: With this short introduction, let us consider what the people aboard ship could do to improve environmental conditions.

The two ships visited were built over 20 years apart but seemed to have the same duct design. There did not appear to be any correlation between the supply and exhaust, so often the supply overpowered the exhaust. Neither was the air supplied in a way to provide either the most benefit in controlling airborne contaminates and/or controlling high temperatures, for the operators.

In most cases the exhaust hoods were either nonexistent, poorly designed, or not properly positioned. There did not appear to be any concentrated effort to control excessive heat being generated within the space.

It is strongly suggested that consideration be given to training a person aboard each ship, in the basics of airflow. This could be done by sending the person to one or more of the three ventilation conferences offered each year, or by having *NEESA put on a training conference.

It there is enough interest, it would be possible to put a course on tape so each ship could have a copy. There are a number of educational tapes on different phases of industrial ventilation that are now available.

This person, trained in the basics of airflow, should then be responsible for any changes in the ventilation control system while at sea and instruct the different operators on how to use the ventilation provided more efficiently. In addition, this person could provide more detailed information on alterations and additions that should be performed when the ship was in port.

This has been the only approach that has been found to be really successful in industry and should work as well for the Navy.

Suggestions for Navy Base Ventilation Personnel: The people in charge of ventilation installation at the Navy bases, should have one or more people trained in the basics of airflow and hood design. They should also have the capability of testing and/or re-testing a system.

It seems there is more printed information and guidelines on heating and air-conditioning than there is on industrial ventilation for contaminant control. They should be considered as two separate trades and have information and trained people for both.

It was not determined if each air handling system is tested to determine if it meets the design criteria before acceptance by the Navy. If they are not, they should be.

Testing of installations in industry determined that installed systems were usually handling air volumes between 50 and 90% of that specified. Additional and alterations should never be made

---

**NEESA, the Naval Energy and Environmental Support Activity, has merged with the Naval Civil Engineering Laboratory and is now called the Naval Facilities Engineering Service Center, Port Hueneme, CA.*

to a system without first determining its static pressure and air volumes. We were told that all decisions are made from the fan catalog ratings, with the assumption that they are correct. Unfortunately, every fan observed was installed with inlet and/or outlet ductwork that would derate it's rating. On a new installation the degree of derating can be estimated, but only by test, and the actual air volume handled by determined.

Every new installation should be tested for air volume and static pressure, and the test information filed. The test information should be available to everyone involved with that system.

If what was observed and what we were told at Norfolk during a visit is typical throughout the Navy, it is doubtful, no matter how much money is spent, that temperatures and airborne contaminates will ever be controlled to a level that will be acceptable to those responsible for the health and well being of Navy personnel.

Twenty-first Century Ship Ventilation: To introduce this subject let's first consider two ventilation problems at opposite ends of the spectrum.

All of us have read of the private, in-board motorboat that has blown up, either when the engine was started or shortly after it left the dock. Usually, there is a statement that the operator had run the fume exhaust fan for some time before starting the engine.

This would make one believe that the exhaust system did not properly vent the space and allowed the fumes to accumulate.

Possible. When the explosion occurred after leaving the dock it is possible, the fumes were above the lower explosive limit, and when the engine was started and later were reduced enough to explode.

Smoke tests have shown that when air is allowed to enter a space through an opening at one end and is then exhausted at the other end of the space the air does not always defuse and flow through all parts of the space. Often the air follows a path through the space and leaves the other parts unvented.

Now lets consider ventilation in the building of a 1,000 foot, double bottom tanker. One such project required the spending of three million dollars on temporary ventilation to exhaust fumes generated by the welders. Because the need for ventilation had not been considered, holes had to be cut in the outer bottom to allow ventilation to be installed. The bottom then had to be patched and ground smooth when the internal work was done.

It would seem that ventilation should be required, as long as that ship is in operation, to provide suitable atmosphere for inspection and maintenance.

This is another example of what can happen if ventilation is not included in the original design.

Before reading Navy manuals, visiting some ships and talking to involved Navy personnel, I believed the greatest opportunity for ventilation improvement on ships would be changing their structural design. The changes would (1) possibly allow the structural members to be used for air ducts and (2) provide adequate space for ductwork, fans and all other equipment required in the many ventilation systems.

I realized the many problems found aboard ship that one does not find in industry but still believed that a great deal could be done, if there were enough interest in doing so. It will require new thinking and changes in plans of long standing, but I believe in time, such changes will be made.

There are a number of things that can and should be done in the immediate future. These include, but are not limited to the following:

1. Update the standards for temperature in all areas of the ship. Although there does not seem to be much of a problem about minimum temperatures, there seems to be a great difference in the standards for upper temperatures. Ventilation design seems to be based on the highest limit recommended, not on temperatures that will allow the person to perform his duties the most efficiently.

2. It is advisable for the Navy to accept and approve standards for the exposure of airborne contaminants, including heat as developed by health authorities.

3. It must be accepted that the control of the industrial environment requires people on the design staff with knowledge of the operations aboard ship, such as industrial hygienists that understand the toxicity of the materials handled or generated aboard ship. There should also be engineers that have an understanding as to how a person reacts to his environment and how to design supply and exhaust ventilation systems to provide a satisfactory temperature and to control all airborne contaminants to an acceptable level.

The environment aboard ship can be updated to an acceptable standard, if people with knowledge of the various phases are made part of the design group, with equal responsibilities and authority.